

**Award Number:**

G17AC00178

**Agency Name:**

University of Nebraska-Lincoln, Conservation and Survey Division.

**Title:**

University of Nebraska-Lincoln, Conservation & Survey Division Proposal for Well Drilling and Well Maintenance of Wells in the National Ground-Water Monitoring Network

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Work for award G17AC00178 was included under Objective 4 and Objective 5. Proposed work under Objective 4 included constructing cattle fencing around 17 sites included in the NGWMN. Objective 4 sites are listed in Table 1.

<b>Well Name</b>	<b>NGWMN Well ID</b>	<b>Repairs Needed</b>
Arthur County	UNL_CSD:8	Replace cattle fencing to protect well and electronics
Brown County	UNL_CSD:41	Replace cattle fencing to protect well and electronics
Buffalo County	UNL_CSD:7	Replace cattle fencing to protect well and electronics
Cherry County	UNL_CSD:46	Replace cattle fencing to protect well and electronics
Garfield County	UNL_CSD:31	Replace cattle fencing to protect well and electronics
Grant County	UNL_CSD:36	Replace cattle fencing to protect well and electronics
Gudmundsen	UNL_CSD:15	Replace cattle fencing to protect well and electronics
Inavale	UNL_CSD:21	Replace cattle fencing to protect well and electronics
Logan County	UNL_CSD:38	Replace cattle fencing to protect well and electronics
McPherson		
County	UNL_CSD:37	Replace cattle fencing to protect well and electronics
N. Lincoln		
County	UNL_CSD:10	Replace cattle fencing to protect well and electronics
SE Cherry County	UNL_CSD:40	Replace cattle fencing to protect well and electronics
Sheridan South	UNL_CSD:22	Replace cattle fencing to protect well and electronics
Sidney	UNL_CSD:23	Replace cattle fencing to protect well and electronics
SW Cherry		
County	UNL_CSD:39	Replace cattle fencing to protect well and electronics
Thomas County	UNL_CSD:42	Replace cattle fencing to protect well and electronics
Trenton	UNL_CSD:35	Replace cattle fencing to protect well and electronics

**Table 1-**Sites proposed for site maintenance under Objective 4.

Work proposed under Objective 5 included replacing 8 NGWMN High Plains Aquifer wells in Nebraska. Proposed replacement wells are listed in Table 2.

<b>Well Name</b>	<b>NGWMN Well ID</b>	<b>Well Depth</b>
Grant County	UNL_CSD:36	150
Logan County	UNL_CSD:38	255
Brown County	UNL_CSD:41	169
SE Cherry County	UNL_CSD:40	272
Buffalo County	UNL_CSD:7	45
Thomas County	UNL_CSD:42	318
SW Cherry County	UNL_CSD:39	300
Sioux North	UNL_CSD:18	110

**Table 2-**Proposed replacement wells under Objective 5. All wells are screened in the High Plains Aquifer.

After initially agreeing to allow the CSD to replace the well on their property, the land owners at the Brown County, and Thomas County sites decided to not allow the CSD to replace the wells, and requested that we remove our equipment from their property. The landowner at

the Buffalo County site requested that we continue using the existing well until it fails, and not replace the well at this time. He did, however, allow us to upgrade the cattle fence at this site. In their place, NGWMN wells listed in Table 3 were replaced, with total drilling footages remaining approximately the same.

Well Name	NGWMN Well ID	Well Depth
Dorchester	UNL_CSD:61, USGS 8N 3E19ADA	255
Plymouth	UNL_CSD:60, USGS 4N 3E13DA	145
N. Lincoln County	UNL_CSD:10	119

**Table 3-**Alternate replacement wells.

Additional cattle fencing was not required at the Plymouth or Dorchester well sites. In place of cattle fencing at these sites, identical fences were constructed at existing NGWMN wells listed in Table 4.

Well Name	NGWMN Well ID
Angora	UNL_CSD:26
Keith County	UNL_CSD:9

**Table 4-** Alternate fencing locations

The changes were approved by Daryll Pope by email on April 12, 2018.

As of March 1<sup>st</sup>, 2020, drilling at all sites has been completed. All wells were drilled to standards set forth by Nebraska Title 178 Chapter 12, using the mud-rotary drilling technique. Drilling was accomplished by a drilling crew employed by the CSD, holding valid Nebraska driller’s licenses. The installation of the 8 new wells will greatly benefit the NGWMN by continuing to provide consistent and reliable groundwater-level data.

All wells were constructed using 4” PVC casing installed in a 9” bored hole. Wells are equipped with 0.010 inch slot screens. Screens were gravel-packed with 16/30 sand from bottom of casing to a minimum of 2’ above the top of the screen. A minimum of 2’ chip bentonite annular seal was used over the gravel pack, and the remaining annular space was pressure grouted with a bentonite slurry. Wells were secured with a locking metal cover, and a minimum 4” thick 24” diameter concrete pad. The surface was backfilled in a manner that allows water to flow away from the wells. Wells were registered with the Nebraska Department of Natural Resources in accordance with State law. Specific well construction information is included in Appendix A.

For groundwater-level data reported to the NGWMN, the measure point of the new well was calculated by comparing the depth to water in the old well to the depth to water in the new well. The measurements at each well were compared several times on subsequent trips at different times of the year. All new measure points remained accurate to within 0.10 inch on all visits.

Drill cuttings at all sites were described and logged by a geologist licensed in the State of Nebraska. Drill cuttings were described to standards set forth by Divine et. al. 2015 and Korus

et. al. 2011. Representative cuttings were sampled for each borehole. Where drilling conditions allowed, samples were collected at a minimum of 5' intervals. When drilling through soft, unconsolidated sand, a bulk representative sample was collected for each geologic unit encountered, and changes in drilling conditions were noted. All collected geologic material has been dried, logged and archived at the Nebraska geologic sample repository. While entering data into the CSD Test Hole Database and NGWMN, inconsistencies in field notes were compared against collected field samples. A summary of the cuttings descriptions are attached in Appendix B, are available on the NGWMN Portal, and are available for download free of charge at: <http://snr.unl.edu/csd/geology/testholes.aspx>

Work Performed under Objective 4 included replacing cattle enclosures to protect well sites and electronics. New cattle enclosures consist of four 4 ½" by 6' or 8' treated corner fence posts, buried to a minimum depth of 38". To the corner posts, four 10' by 4' steel corral panels were permanently attached. An example enclosure is pictured in Figure 1. No data was collected during the construction of the cattle enclosures.



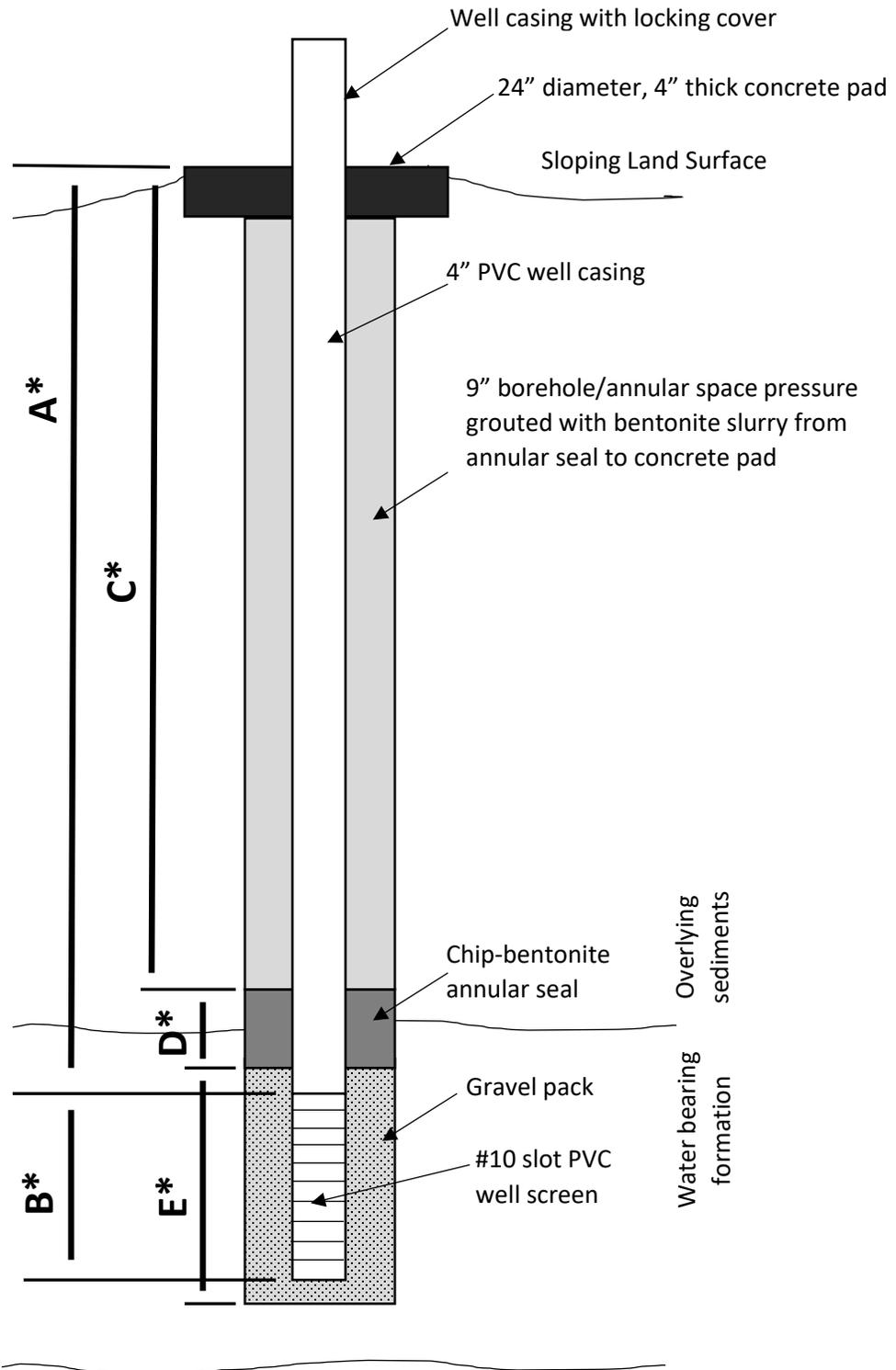
**Figure 1**-Example of cattle enclosure construction.

## **Works cited**

Divine, Dana P., Joeckel, R.M., Korus, Jesse T. 2015. Basic Guide for Description of Cuttings from Boreholes in Nebraska. Lincoln, NE: Conservation and Survey Division, UNL. pp. 36.

Korus, J.T., Joeckel, R.M., Hanson, P.R., Goeke, J.W., Lackey, S.O., and Burbach, M.B. 2011. Reference List For Describing Cuttings And Cores Of Sediments And Sedimentary Rocks In Nebraska

Nebraska Department of health and Human Services Division of Public Health, 2014. Regulations Governing Water Well Construction, Pump Installation, and Water Well Decommissioning Standards. Nebraska Title 178 Chapter 12.



Generalized well construction diagram. Dimensions A\*, B\*, C\*, D\* and E\* are provided for each well in Appendix A.

**Appendix A- Well Construction Information**

Grant County-UNL\_CSD:36

G-

NE-DNR Registration 186345

UNL-CSD Test Hole

Number 03-UL-18

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	165	casing (Dimension A*)	4	4.5	0.25	pvc	
165	180	screen (Dimension B*)	4	4.5	0.25	pvc	0.01

Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	158	grout (Dimension C*)	EZ-Seal		15 bags of slurry
158	163	annular seal (Dimension D*)	3/8 Holeplug		2 bags of chip
163	180	gravel (Dimension E*)	16/30 Best Sand	13 bags	

Logan County-

UNL\_CSD:38

G-

NE-DNR Registration 189351

UNL-CSD Test Hole

Number 01-UL-20

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	236	casing (Dimension A*)	4	4.5	0.25	pvc	

236	256	screen (Dimension B*)	4	4.5	0.25	pvc	0.01
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Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	225	grout (Dimension C*)	EZ-Seal		12 bags of slurry
225	234	annular seal (Dimension D*)	3/8 Holeplug		3 bags of chip
234	256	gravel (Dimension E*)	16/30 Best Sand	16 bags	

Dorchester-UNL\_CSD:61

G-  
 NE-DNR Registration 186341  
 UNL-CSD Test Hole 01-LBB-  
 Number 18

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	135	casing (Dimension A*)	4	4.5	0.25	pvc	
135	145	screen (Dimension B*)	4	4.5	0.25	pvc	0.01

Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	128	grout (Dimension C*)	EZ-Seal		12 bags of slurry
128	133	annular seal (Dimension D*)	3/8 Holeplug		2 bags of chip
133	150	gravel (Dimension E*)	16/30 Best Sand	15 bags	

SE Cherry County-UNL\_CSD:40

G-  
 NE-DNR Registration 186344

UNL-CSD Test Hole

Number

01-UL-18

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	255	casing (Dimension A*)	4	4.5	0.25	pvc	
255	270	screen (Dimension B*)	4	4.5	0.25	pvc	0.01

Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	248	grout (Dimension C*)	EZ-Seal		23 bags of slurry
248	253	annular seal (Dimension D*)	3/8 Holeplug		2 bags of chip
253	270	gravel (Dimension E*)	16/30 Best Sand	16 bags	

N. Lincoln County-UNL\_CSD:10

G-

NE-DNR Registration

189350

UNL-CSD Test Hole

Number

01-NP-20

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	109	casing (Dimension A*)	4	4.5	0.25	pvc	
109	119	screen (Dimension B*)	4	4.5	0.25	pvc	0.01

Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	95	grout (Dimension C*)	EZ-Seal		10 bags of slurry

95	106	annular seal (Dimension D*)	3/8 Holeplug		3 bags of chip
106	119	gravel (Dimension E*)	16/30 Best Sand	8 bags	

Plymouth-UNL\_CSD:60

G-  
 NE-DNR Registration 186340  
 UNL-CSD Test Hole 02-LBB-  
 Number 18

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	245	casing (Dimension A*)	4	4.5	0.25	pvc	
245	255	screen (Dimension B*)	4	4.5	0.25	pvc	0.01

Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	238	grout (Dimension C*)	EZ-Seal		20 bags of slurry
238	243	annular seal (Dimension D*)	3/8 Holeplug		2 bags of chip
243	255	gravel (Dimension E*)	16-30 Best Sand	7 bags	

SW Cherry County-UNL\_CSD:39

G-  
 NE-DNR Registration 186346  
 UNL-CSD Test Hole  
 Number 02-UL-18

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	250	casing (Dimension A*)	4	4.5	0.25	pvc	

250	270	screen (Dimension B*)	4	4.5	0.25	pvc	0.01
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Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	231	grout (Dimension C*)	EZ-Seal		22 bags of slurry
231	236	annular seal (Dimension D*)	3/8 Holeplug		2 bags of chip
236	270	gravel (Dimension E*)	16/30 Best Sand	23 bags	

Sioux North UNL\_CSD:18

NE-DNR Registration      G-  
 UNL-CSD Test Hole      186342  
 Number                      01-UNW-18

Casing and Screen

From Depth	To Depth	Casing or Screen	Inside Diameter	Outside Diameter	Case Thickness	Material	Slot Size
0	95	casing (Dimension A*)	4	4.5	0.25	PVC	
95	110	screen (Dimension B*)	4	4.5	0.25	PVC	0.01

Grout and Gravel

From Depth	To Depth	Interval Unit	Material	Quantity	Volume
0	82	grout (Dimension C*)	EZ-Seal		8 bags of slurry
82	87	annular seal (Dimension D*)	3/8 Holeplug		2 bags of chip
87	110	gravel (Dimension E*)	16/30 Best Sand	16 bags	

**Appendix B- Well Lithology**

Well ID	Lithologic Unit	Lithologic Description	From Depth	To Depth
Grant County-UNL_CSD:36	sand	sand, very fine to medium, slightly silty, dark brown	0	5
Grant County-UNL_CSD:36	sand	sand, fine to medium, light tan, very slightly silty	5	10
Grant County-UNL_CSD:36	sand	sand, very fine to medium, light tan, All same 10' thru 20'	10	20
Grant County-UNL_CSD:36	sand	sand, very fine to fine, light tan, All same 20' thru 35'	20	35
Grant County-UNL_CSD:36	sand	sand, very fine to coarse, light tan, angular grains	35	40
Grant County-UNL_CSD:36	sand	same as above, very slightly silty	40	45
Grant County-UNL_CSD:36	sand, silt	bedded sand, very fine to medium sand with silt, very clayey, gray, with moderate very fine to fine sandy, 45' - 50' laminated silts and sands, 50' - 60' very fine to fine sand slightly silty	45	60
Grant County-UNL_CSD:36	sand	sand, very fine to fine, slightly silty, light tan	60	75
Grant County-UNL_CSD:36	silt, clay, sand	laminated silt, slightly clayey with sand fine to coarse, drilled slower at 75' - 82'	75	82
Grant County-UNL_CSD:36	silt, clay, sand	same as above, drilled faster	82	87
Grant County-UNL_CSD:36	silt, sand	silt, very fine to medium sandy, gray, drilled slower	87	90
Grant County-UNL_CSD:36	silt, clay	silt, slightly clayey, very fine to medium sandy, gray, drilled slow	90	95
Grant County-UNL_CSD:36	silt, clay	silt, moderately clayey, very fine to medium sandy, All same 95' thru 138'	95	138
Grant County-UNL_CSD:36	sandstone	probably brown hard medium to coarse sandstone, possibly bedded with gray silt and clay	138	150
Grant County-UNL_CSD:36	sand	sand, probably medium to coarse sand, possibly with beds of silts and clays?	150	165
Grant County-UNL_CSD:36	sand	sand, very fine to coarse, probably with beds of silts and clays	165	180
Logan County-UNL_CSD:38	Sand	Sand, fine to medium	1	15
Logan County-UNL_CSD:38	Sand, silt	Sand, fine to medium, slightly silty	15	39.5
Logan County-UNL_CSD:38	Sandstone, coarse	Sandstone, Ogallala Fm. Moderately cemented, coarse	39.5	156
Logan County-UNL_CSD:38	Sandstone, gravel	Sandstone, Ogallala Fm. Slightly cemented, coarse sand, fine gravel	156	194.5
Logan County-UNL_CSD:38	Sandstone, coarse	Sandstone, Ogallala Fm. Slightly Cemented, coarse sand	194.5	260
Dorchester-UNL_CSD:61	silt, clay	silt, very clayey, light reddish-brown, Peoria Loess, even drilling action 0' thru 50'	0	7
Dorchester-UNL_CSD:61	silt	silt, slightly clayey, light brown, Peoria Loess	7	13

Dorchester-UNL_CSD:61	silt	silt, slightly clayey, moderate very fine sandy, light brown, Peoria Loess	13	15
Dorchester-UNL_CSD:61	silt, clay	bedded silt and clay? Very sandy, reddish-brown	15	20
Dorchester-UNL_CSD:61	silt	silt, light brown, poor recovery, lost mud	20	30
Dorchester-UNL_CSD:61	silr	silt, slightly clayey, slight medium to fine sandy, light reddish-brown	30	36
Dorchester-UNL_CSD:61	sand, silt	very fine sand, very silty, light gray-tan	36	40
Dorchester-UNL_CSD:61	sand, silt	same as above, possibly with thin beds of red medium sand	40	45
Dorchester-UNL_CSD:61	sand, silt	same as above, with slight very coarse sand last foot	45	50
Dorchester-UNL_CSD:61	sand	sand, medium to fine gravel, mostly quartz and pink feldspar, All same 50' thru 60', crunchy drilling action	50	60
Dorchester-UNL_CSD:61	sand	sand, medium to coarse, light brown, even to crunchy drilling action	60	65
Dorchester-UNL_CSD:61	sand	sand, medium to very coarse, slightly coarser than above, even to crunchy drilling action	65	70
Dorchester-UNL_CSD:61	no sample	no sample, probably as above, even drilling action 70' thru 105'	70	75
Dorchester-UNL_CSD:61	sand	sand, very fine to coarse, possibly silty beds throughout	75	80
Dorchester-UNL_CSD:61	silt	silt, fine to medium sandy? Light pink	80	85
Dorchester-UNL_CSD:61	silt	silt, very sandy? Medium to fine sand, light tan	85	90
Dorchester-UNL_CSD:61	sand	sand, medium to coarse?	90	95
Dorchester-UNL_CSD:61	sand	medium sand, slightly silty, All same 95' thru 105'	95	105
Dorchester-UNL_CSD:61	sand	poor cuttings, mostly medium to coarse sand slight to moderate, very coarse sandy and fine gravely, mostly medium to coarse sand in cuttings pile from sand separator	105	120
Dorchester-UNL_CSD:61	sand	sand, medium to very coarse, moderately fine gravely	120	125
Dorchester-UNL_CSD:61	sand	same as above, trace gravel	125	130
Dorchester-UNL_CSD:61	sand	sand, coarse to very coarse, moderately fine gravely	130	135
Dorchester-UNL_CSD:61	sand	sand, fine to very coarse, trace fine gravel	135	140
Dorchester-UNL_CSD:61	sand	same as above, moderately fine gravely	140	145
Dorchester-UNL_CSD:61	sand	same as above? No sample	145	148
Dorchester-UNL_CSD:61	clay	clay, blue, dense, probably glacial origin	148	150
SE Cherry County-UNL_CSD:40	silt, sand	silt, very medium sandy, dark brown	0	5

SE Cherry County-UNL_CSD:40	sand, silt	sand, medium, moderately silty, light tan	5	10
SE Cherry County-UNL_CSD:40	sand	sand, medium, slightly silty, light tan-gray	10	15
SE Cherry County-UNL_CSD:40	sand	sand, medium, clean, light tan	15	20
SE Cherry County-UNL_CSD:40	sand	sand, fine to medium, possible bedded organic silt/clay	20	25
SE Cherry County-UNL_CSD:40	sand	same as above, possible Ogallala at 29.5'	25	30
SE Cherry County-UNL_CSD:40	sand	same as above, layers of thin sandstone	30	35
SE Cherry County-UNL_CSD:40	sand	sand, fine to medium, slightly silty, light tan	35	40
SE Cherry County-UNL_CSD:40	sand	sand, fine to medium, very silty, tan, All same 40' thru 55'	40	55
SE Cherry County-UNL_CSD:40	siltstone	siltstone, tan, sandy very fine to coarse	55	60
SE Cherry County-UNL_CSD:40	sandstone	sandstone, weakly cemented, very fine to coarse beds of tan siltstone	60	65
SE Cherry County-UNL_CSD:40	Ogallala, sand	Ogallala, sand and sandstone, very fine to coarse, trace fine gravel, rootlets, beds of gray siltstone, All same 65' thru 75'	65	75
SE Cherry County-UNL_CSD:40	sandstone	very poorly cemented sandstone, fine to coarse, layers of well cemented white coarse sandstone, rootlets	75	80
SE Cherry County-UNL_CSD:40	sandstone	same as above, moderately cemented	80	85
SE Cherry County-UNL_CSD:40	sandstone	same as above 85' thru 95'	85	95
SE Cherry County-UNL_CSD:40	sandstone	sandstone, dark brown, fine to medium, rootlets, siltstone layers throughout, All same 95' thru 130', Hackberry at 110' - 115'	95	130
SE Cherry County-UNL_CSD:40	ash	ash, white, possibly sandy, crunchy drilling action	130	135
SE Cherry County-UNL_CSD:40	ash	ash, same as above with beds of tan-olive, medium sandstone, crunchy drilling action 135' - 150', even to crunchy drilling 150' - 160' All same 135' thru 160'	135	160
SE Cherry County-UNL_CSD:40	sandstone	sandstone, medium to coarse, many rootlets, brown	160	165
SE Cherry County-UNL_CSD:40	sandstone	sandstone, very fine to coarse, many rootlets, brown, hard, even drilling action, All same 165' thru 180'	165	180
SE Cherry County-UNL_CSD:40	sandstone	sandstone, white, very fine to coarse, bedded with gray marl, rough drilling action	180	186
SE Cherry County-UNL_CSD:40	sandstone	sandstone, brown, very fine to medium, trace rootlets, All same 186' thru 210', softer at 195' - 205', hard at 205' - 210'	186	210
SE Cherry County-UNL_CSD:40	sandstone	sandstone, very fine to fine, slightly silty, brown, few rootlets, All same 210' thru 225'	210	225
SE Cherry County-UNL_CSD:40	sandstone	sandstone, same as above, marl at 228' - 229'	225	230

SE Cherry County-UNL_CSD:40	sandstone	sandstone, same as above, marl at 234' - 235'	230	235
SE Cherry County-UNL_CSD:40	sandstone	sandstone, same as above, marl at 237' - 238'	235	240
SE Cherry County-UNL_CSD:40	sandstone	sandstone, very fine to fine, poorly to moderately well cemented, brown, few trace rootlets, All same 240' thru 255'	240	255
SE Cherry County-UNL_CSD:40	sandstone	sandstone, same as above, hard, no rootlets, All same 255' thru 265'	255	265
SE Cherry County-UNL_CSD:40	ash	ash white	265	270
N. Lincoln County-UNL_CSD:10	sand	Sand, medium to coarse, mostly quartz, well rounded lt brown	0	10
N. Lincoln County-UNL_CSD:10	sand, silt	Sand, fine to coarse, slightly to moderately silty, mostly quartz, well rounded lt brown	10	30
N. Lincoln County-UNL_CSD:10	silt, sand	Silt, moderately very fine sandy, gray tan	30	35
N. Lincoln County-UNL_CSD:10	sand, silt	Sand, Fine to coarse, slightly to moderately silty	35	50
N. Lincoln County-UNL_CSD:10	Sand	Sand, coarse to medium, slightly silty	50	59
N. Lincoln County-UNL_CSD:10	mudstone	Mudstone, silt, moderately very fine to medium sandy, gray Ogallala Fm.	59	75
N. Lincoln County-UNL_CSD:10	Sand	Sand, medium to coarse, moderately to very silty, gray	75	85
N. Lincoln County-UNL_CSD:10	Mudstone	Mudstone, silt, moderately very fine to medium sandy, gray Ogallala Fm.	85	110
N. Lincoln County-UNL_CSD:10	sand	Sand, medium to fine, trace coarse, clean	110	119
Plymouth-UNL_CSD:60	clay, silt	clay, very silty, black, even drilling action 0' thru 45', non calcareous 0' thru 45'	0	2.5
Plymouth-UNL_CSD:60	silt, clay	silt, moderately clayey, gray-olive, iron concentrations throughout, All same 2.5' thru 10'	2.5	10
Plymouth-UNL_CSD:60	silt	silt, slightly clayey, dark brown, G CF? Ref field log	10	11
Plymouth-UNL_CSD:60	clay	clay, slightly silty, (4+" ribbon) red, stiff, Loveland	11	15
Plymouth-UNL_CSD:60	clay	same as above, slightly yellower, All same 15' thru 25'	15	25
Plymouth-UNL_CSD:60	clay, silt	clay, very silty, gray throughout, stiff, iron oxide staining	25	27
Plymouth-UNL_CSD:60	silt, clay	silt, clayey, gray-tan, iron staining throughout	27	28
Plymouth-UNL_CSD:60	clay	clay, slightly silty, tan-gray, iron staining throughout, All same 28' thru 35'	28	35
Plymouth-UNL_CSD:60	clay, silt	clay, very silty, trace sand? Gray-tan, slightly redder last foot, Till present 35' thru 60'	35	41
Plymouth-UNL_CSD:60	silt, clay	silt, clayey, slight moderately sandy, trace fine gravel, yellow-ocher, till	41	45

Plymouth-UNL_CSD:60	clay	clay, silty moderately very fine to medium sandy, trace fine gravel, yellow, angular lithic fragments, calcium carbonate concentrations throughout, possible black clay beds, crunchy drilling action, All same 45' thru 59'	45	59
Plymouth-UNL_CSD:60	sand	sand, very fine to coarse, slight fine gravely, slightly clayey, calcareous, Till	59	60
Plymouth-UNL_CSD:60	sand	sand, medium to very coarse, slight to medium fine gravely, ironstone beds top foot, Sioux quartzite boulder at 63', rough drilling action, calcareous	60	65
Plymouth-UNL_CSD:60	sand	sand, fine to medium, silty few dark lithic fragments throughout, beds of fine to coarse sand? Crunchy to even drilling action, calcareous, All same 65' thru 75'	65	75
Plymouth-UNL_CSD:60	sand	sand, fine to medium, tan, even drilling action, slightly calcareous, All same 75' thru 90'	75	90
Plymouth-UNL_CSD:60	sand	sand, very fine to fine, possible tan silt beds, even drilling action, non calcareous 90' thru 255'	90	95
Plymouth-UNL_CSD:60	sand	sand, very fine to fine, silty, soft, possibly beds of silt/clay, even drilling action	95	100
Plymouth-UNL_CSD:60	silt	silt, very to very fine sandy, loose, soft, tan, even drilling action	100	105
Plymouth-UNL_CSD:60	sand	sand, fine to very coarse, light colored, quartz and feldspar grains, crunchy drilling action	105	110
Plymouth-UNL_CSD:60	sand	sand, medium to very coarse, trace gravel, crunchy drilling action, All same 110' thru 125'	110	125
Plymouth-UNL_CSD:60	sand	sand, coarse to very coarse, slight to moderately sandy, trace fine gravel, crunchy to rough drilling action	125	130
Plymouth-UNL_CSD:60	sand	sand, fine to coarse, mostly fine to medium, crunchy drilling action, All same 130' thru 140'	130	140
Plymouth-UNL_CSD:60	gravel	gravel, fine, with medium to coarse sand, red feldspar and quartz grains, crunchy drilling action	140	145
Plymouth-UNL_CSD:60	sand	sand, very fine, moderately silty, somewhat stiff, crunchy drilling action	145	150
Plymouth-UNL_CSD:60	sand	sand, fine to very coarse, probably mostly fine to medium? Even to crunchy drilling action	150	155
Plymouth-UNL_CSD:60	sand	same as above, possible trace gravel, even to crunchy drilling action	155	160
Plymouth-UNL_CSD:60	sand	sand, fine to very coarse, moderately fine gravely, even to crunchy drilling action, All same 160' thru 185' Slightly coarser at 175'?	160	185

Plymouth-UNL_CSD:60	no sample	no sample collected, bit plugged and popped over pressure on rig, sample collected is much coarser than what is coming off mud separator, Ref field log	185	190
Plymouth-UNL_CSD:60	sand	mostly very coarse sand and fine gravel collected, mostly medium to coarse, sand off mud separator, even to crunchy drilling action	190	195
Plymouth-UNL_CSD:60	sand	sand, very fine to coarse with beds of silt/clay, stiff, yellow-tan, gravel is likely lag, even drilling action	195	200
Plymouth-UNL_CSD:60	sand, gravel	sand and gravel? Poor cuttings, drilled like fine sand?, even drilling action	200	205
Plymouth-UNL_CSD:60	sand	sand, medium to coarse, moderately very gravelly, lots of pink feldspar, even to crunchy drilling action, All same 205' thru 215'	205	215
Plymouth-UNL_CSD:60	sand	same as above, less gravel, trace to slight fine gravelly, even to crunchy drilling action	215	220
Plymouth-UNL_CSD:60	sand	same as above, change from pink-white feldspar, even drilling action 220' thru 255', Dakota 220' thru 255'	220	225
Plymouth-UNL_CSD:60	sand	sand, medium to very coarse with fine gravel, Dakota, All same 225' thru 235'	225	235
Plymouth-UNL_CSD:60	sand	same as above, possible clay/mudstone layer at base?, Dakota	235	240
Plymouth-UNL_CSD:60	sand	sand, medium to coarse, Dakota	240	245
Plymouth-UNL_CSD:60	sand	sand, fine to coarse, well rounded quartz and white feldspar, Dakota	245	250
Plymouth-UNL_CSD:60	sand	same as above, Dakota, Total Depth 255'	250	255
SW Cherry County-UNL_CSD:39	sand	sand, very fine to medium, moderately silty, tan, even drilling action, 0' - 50'	0	15
SW Cherry County-UNL_CSD:39	sand	same as above, less silt last 5'	15	30
SW Cherry County-UNL_CSD:39	sand	sand, very fine to fine, very silty, tan, ONE SAMPLE BAG 30' THRU 50', All same 30' thru 50'	30	50
SW Cherry County-UNL_CSD:39	sand	sand, same as above with thin beds of silt, drilling slowed at 57', crunchy drilling action	50	57
SW Cherry County-UNL_CSD:39	sand	bedded very fine to fine sand, very silty with layers of silt, slight clayey, beds are thin,	57	60
SW Cherry County-UNL_CSD:39	sand	same as above, drilling action slowed at 61'	60	65

SW Cherry County- UNL_CSD:39	silt	silt, moderately clayey, very fine to fine sandy, tan, All same 65' thru 80'	65	80
SW Cherry County- UNL_CSD:39	sandstone	sandstone, very fine to medium, moderately silty, possible layers of white silt, white lime cemented	80	84
SW Cherry County- UNL_CSD:39	sandstone	same as above, more medium sand, slightly cemented	84	90
SW Cherry County- UNL_CSD:39	sandstone	sandstone, very fine to coarse, slightly silty, moderately cemented, brown, Possibly Ogallala? Rough drilling action 90' - 120'	90	98.5
SW Cherry County- UNL_CSD:39	sandstone	same as above with soft silt at 8.5' silts white, limey probably thinly bedded	98.5	105
SW Cherry County- UNL_CSD:39	sandstone	sandstone, very fine to coarse, brown, well cemented, few rootlets	105	120
SW Cherry County- UNL_CSD:39	sandstone	same as above, sand fine to coarse, Crunchy drilling action 120' thru 215'	120	135
SW Cherry County- UNL_CSD:39	sandstone	same as above, slightly softer, few thin beds of yellow silty soft sand	135	150
SW Cherry County- UNL_CSD:39	sandstone	sandstone, fine to coarse trace very coarse, brown, few beds of yellow silty very fine to medium sand, soft sandstone, well cemented	150	165
SW Cherry County- UNL_CSD:39	sandstone	same as above, slightly softer	165	180
SW Cherry County- UNL_CSD:39	sandstone	same as above, few rootlets, All same 180' thru 215'	180	215
SW Cherry County- UNL_CSD:39	sand	sand, fine to coarse, moderate to very silty, tan, All same 215' thru 230', even drilling action	215	230
SW Cherry County- UNL_CSD:39	sandstone	sandstone, fine to coarse sand, moderately well cemented, tan	230	240
SW Cherry County- UNL_CSD:39	sandstone	sandstone, same as above, possibly few beds of gray silt, very fine sandy beds are probably less than 1 cm, silt beds are likely rare	240	255
SW Cherry County- UNL_CSD:39	sandstone	same as above? 255' - 265' probably siltier sand? Poor cuttings caught, lots of silty very fine sand in mud separator Total Depth 270'	255	270
Sioux North UNL_CSD:18	fill sand	road and railroad fill sand, fine to very fine, even drilling action 0' thru 20'	0	11
Sioux North UNL_CSD:18	sandstone	sandstone, very fine to medium, possibly slightly silty, well cemented, brown	11	15
Sioux North UNL_CSD:18	sandstone	sandstone, very fine to medium to very coarse, brown, few rootlets, well cemented	15	20
Sioux North UNL_CSD:18	sandstone	same as above, white chert beds last 1', well cemented, crunchy drilling action	20	25

Sioux North UNL_CSD:18	sandstone	same as above, many white chert layers, well cemented, moderately rough drilling action	25	30
Sioux North UNL_CSD:18	sandstone	same as above, some white chert beds, moderately cemented, possible thin coal beds, moderately rough drilling action	30	35
Sioux North UNL_CSD:18	sandstone	same as above, even drilling action	35	40
Sioux North UNL_CSD:18	sandstone	same as above, crunchy drilling action, All same 40' thru 51'	40	51
Sioux North UNL_CSD:18	sandstone	sandstone, very fine to medium, lime cemented, very hard, brown, very rough. Slow drilling 20 minute 3', moderately rough drilling action	51	53
Sioux North UNL_CSD:18	sandstone	sandstone, fine to coarse, moderately well cemented, brown, few sandy mudstone beds, white, crunchy drilling action	53	60
Sioux North UNL_CSD:18	sandstone	same as above, hard at 63' - 64', rough drilling action, All same 60' thru 71'	60	71
Sioux North UNL_CSD:18	sandstone	same as above, white chert, opal? Beds? Very well cemented! 20 minutes	71	75
Sioux North UNL_CSD:18	sandstone	sandstone, same as above, moderately well cemented, crunchy drilling action, All same 75' thru 105'	75	105
Sioux North UNL_CSD:18	sandstone	sandstone, same as above, softer	105	110